

# A Remark on "A CMB/Dark Energy Cosmic Duality"

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The recent calculation on the suppression of the power at low multipoles in the CMB spectrum due to an IR cut-off presented in hep-th/0406019 does not take into account the Integrated Sachs-Wolfe (ISW) term, which is crucial in models aiming to the explanation of the present acceleration of the Universe. We show that the ISW contribution to low multipoles is typically much greater than the SW term, for an IR cut-off comparable to the present Hubble radius.

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Recently an attempt to lower the quadrupole of the CMB temperature anisotropies pattern by imposing an IR cut-off has been tried in [1]. The IR cut-off is imposed for a flat universe in the relation between the multipoles of the CMB anisotropy pattern and scalar metric fluctuations in Fourier space. Such relation for an adiabatic scale invariant spectrum is [2]:

$$\langle \left( \frac{\Delta T}{T} \right)^2 \rangle_\ell = \frac{A^2}{100 \pi \ell (\ell + 1)} K_\ell^2, \quad (1)$$

where  $A$  is the amplitude of gravitational fluctuations and the coefficient  $K_\ell^2$  is given by [2]

$$\begin{aligned} K_\ell^2 &= 200 \ell (\ell + 1) \int_{k_c}^{\infty} \frac{dk}{k} \left[ \frac{1}{10} j_\ell(k(\eta_0 - \eta_r)) + \right. \\ &\quad \left. + \int_{\eta_r}^{\eta_0} d\eta \frac{df}{d\eta} j_\ell(k(\eta_0 - \eta)) \right]^2 \\ &\equiv \int_{s_c}^{\infty} ds [I_{\ell \text{ SW}}(s) + I_{\ell \text{ ISW}}(s)]^2 \end{aligned} \quad (2)$$

where  $s = k/H_0$ ,  $\eta_r$ ,  $\eta_0$  are the conformal times at recombination and at present, respectively.  $k_c$  is an IR cut-off and the function  $f$ , defined as

$$f(\eta) = 1 - \frac{a'}{a^3} \int_0^\eta d\tau a^2(\tau), \quad (3)$$

describes the time-dependence of metric fluctuations in a  $\Lambda$ CDM scenario.

The ISW term is zero in a CDM scenario (where  $K_\ell = 1$ ), while is actually of the same order of magnitude of the SW term at low  $\ell$  in presence of  $\Lambda$  [2]. All the results presented here are obtained with  $\Omega_\Lambda^0 = 0.75$ ,  $\Omega_b^0 = 0.05$ ,  $\Omega_{\text{CDM}}^0 = 0.2$ ,  $h = 0.7$  (the same as in [1]).

The integrands of the SW and ISW contributions look very different, as shown in Fig. 1 for  $\ell = 2$ . An IR cut-off can easily kill the SW term, but not the ISW term

since its shape is broader in Fourier space. Table 1 shows how the SW term is reduced by two orders of magnitude, while the ISW term is almost unchanged.

Fig. 2 shows the CMB temperature power spectrum computed by CMBFAST [3]. Note that the introduction

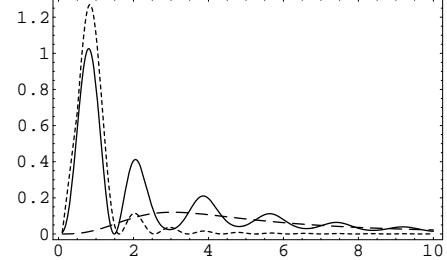


FIG. 1:  $I_2^2 \text{ SW}$  (short-dashed),  $I_2^2 \text{ ISW}$  (long-dashed) and the total  $(I_2^2 \text{ SW} + I_2^2 \text{ ISW})^2$  (solid) with respect to  $s = k/H_0$ . The IR cut-off used in [1] corresponds to  $s_* \simeq 2.6$ .

$s_c = k_c/H_0$	$K_2^2$	SW	ISW
$\pi 10/12$	0.500	0.035	0.594
$1/10$	1.544	0.999	0.600

TABLE I: Numerical values of  $K_2^2$  (and the relative SW and ISW contributions) for the IR cut-off chosen in [1] and for a much smaller cut-off (not zero for numerical reason).

of an IR cut-off of the same magnitude as in [1] reduces the low tail of the CMB power spectrum approximately to one third of the  $\Lambda$ CDM value, in agreement with Table 1 and in contrast with Fig. 1 of [1]. Our result is also in agreement with [4].

We finally note that, for the cut-off chosen in [1], Fig. 1 shows that the ISW term is larger than the SW term, *independently* from the discretization procedure used in [1], which substitutes the integral in Eq. (2) with a sum as in Eq. (6) of [1].

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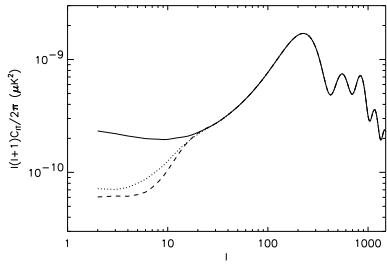


FIG. 2: CMB temperature power spectrum computed with CMBFAST: the solid line is a  $\Lambda$ CDM model without IR cutoff, the dashed line has an IR cut-off, the dotted line has the same IR cut-off, but a different window function.

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